International Research Journal on Advanced Engineering and Management
https://goldncloudpublications.com
https://doi.org/10.47392/IRJAEM.2024.0176

e ISSN: 2584-2854
Volume: 02
Issue: 05 May 2024
Page No: 1297-1301

Effect of Drying on The Physical Characteristics of Mizo Chilli (Bird's Eye Chilli) and Study of Its Drying Kinetics

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Abstract

Mizo chilli (Bird's eye chilli), locally known as Hmarchate or Vaihmarchate is one of the hottest chillies in the world and a major spice crop of Mizoram. Traditional sun-drying at temperatures around 33±2℃ and hot air oven drying at 40°C, 50℃ and 60℃ was carried out using the green chillies (grade B and C) having lengths of around 2.5 cm–4 cm. The initial moisture content of the fresh chillies was 78±5% (wb) having a water activity of 0.981±0.017, and it was dried to a final moisture content of 6±2% (wb). The time required for sun drying was around 30 h which was done during the daytime of bright sunny days. The hot air oven drying at 40°C, 50℃, and 60℃ were completed in 26 h, 24 h, and 23 h respectively. The color variation of the samples was measured using a hunter lab calorimeter. The water activity (aw) of the sun-dried samples was 0.407±0.004 and that of the hot air-dried samples was 0.551±0.003. The sun drying gave a better appearance than the hot air drying. Studying the drying behavior and kinetics of the samples, the Page model was best fitted for sun drying while the Lewis model was found to be best fitted for hot air oven drying.

Keywords: *Mizo chilli (bird's eye chilli), moisture content, color variation, water activity, drying kinetics*

1. Introduction

Mizo chilli (bird's eye chilli), locally known as Hmarchate or Vaihmarchate, [4] is one of the hottest chilies in the world and a major spice crop of Mizoram and it belongs to the species Capsicum frutescens [1] (Dutta et al.,2016). Because of its unique aroma and high pungency, it has received high attention throughout the country. It has been recognized as a Geographical indication of Mizoram by the Government of India in 2015 [2] (Majumder et al.,2023). The SHU count of the mizo chilli is around 50,000-100,000 [3] (Lalhminghlui et al., 2020). It is divided into three grades: Grade A- It has a length of about 1cm. It is the smallest, and thinnest, but has the most pungency and thus its demand is the highest. Grade B- About 2.5cm in length and slightly thicker than grade A. Grade C- About 3-4.5cm in length but the thickness is almost similar to grade B. To boost the income of the farmers and expand the market of the Mizo chilli, Mizoram Government has initially started exporting around 7.5 metric tons of the chilli to the United States (Zolianzuali et al.,2023). Preservation of the chilli is important as its production is highest between November to March and large quantity of the chilli is lost without proper processing and storage. Despite having a significant chilli production, Mizoram lacks good processing and storage facilities which resulted in daily wastage of the chillies [5] (Phairong et al., 2020). Drying, an old and easy method of food preservation is conducted by removing the moisture present in the food by the application of heat and helps in preserving the food products for future usage [6] (Sagar and Kumar, 2010). Drying of the Bird's eye chilli and producing value-added products will help increase the economy of Mizoram.

1.1. Traditional Drying

Sun drying, a traditional drying technique of agricultural products has been practiced for centuries around the world. It helps preserve the products for a longer duration by using the sun's heat and energy to remove the moisture content of the food item. Sun drying is a low-cost drying method but it is highly dependent on the climatic conditions and thus it is not a time-effective technique [7] (Gupta et al.,2018).

1.2. Oven Drying

Hot air oven drying is a widely used drying technique because it produces homogeneous heating, a relatively fast drying time, and hygienic food products. Vegetables are mostly dried at temperatures 40°C to 70°C in a hot air oven which helps in reducing the time for drying as compared to traditional sun drying [8] (Toontom et al.,2012). The study is aimed to dry the Mizo chilli (bird's eye chilli) by sun drying and hot air oven drying at different temperatures to determine the physical changes, color variation and water activity of the dried product. The behavior and kinetics of drying according to the drying time at various temperatures will also be studied. By studying the various parameters of the drying techniques, the feasibility of the drying method will also be determined in Figure 1&2.

Figure 1 **Mizo Chilli (Bird's Eye Chilli)**

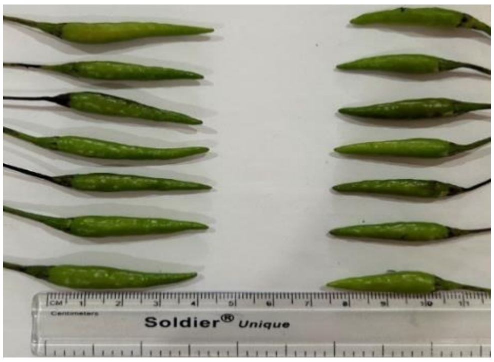

Figure 2 **Grade B and C Mizo Chilli for Drying**

2. Materials and Methods

2.1. Raw Material

The Mizo chilli (bird's eye chilli) was bought from a nearby market in Ramrikawn, Aizawl. The green mizo chillies of grades B and C having lengths of around 2.4cm – 4cm were selected for drying. The chillies were then sorted, washed, and cleaned thoroughly. The initial weights of the raw samples were taken.

2.2. Drying

The mizo chillies were dried using traditional sun drying and hot air oven drying techniques. Traditional sun drying: The fresh green chillies were sun-dried at a temperature of around 33±2 °C during the daytime on bright sunny days. This drying technique highly depended on the climatic situation and hence it took longer days to fully dry the product. The weight of the samples at various time intervals was taken till the weight became uniform [9, 17] (Tunde-Akintunde et al.,2004). The complete drying took about 30 h. Hot air oven drying: A hot air oven was used to dry the fresh green mizo chillies at 40°C, 50°C, and 60°C. The oven was preheated at the different temperatures before placing the samples. The chillies were weighed at various time intervals until the weight change was constant [10] (Getahun et al.,2021). The hot air oven drying at 40°C, 50°C, and 60°C were completed in 26 h, 24 h, and 23 h respectively.

2.3. Determination of Moisture Content

The moisture content was computed using the following formula while utilizing the [11] AOAC method (A.O.A.C, 1995) for both drying processes.

$$Moisture\ content\ (\%) = \frac{loss\ in\ weight\ (g)}{weight\ of\ the\ sample\ (g)}\ X\ 100 \qquad (1)$$

2.4. Determination of Water Activity

Water activity (aw), a measure of the quantity of water accessible for microbial growth and chemical reactions in food products, has a significant impact on food spoilage. It was measured using a water activity analyzer (Pre-Aqua Lab) [12] (Rhim, et al., 2011) in table 2.

2.5. Colour Measurements

HunterLab's colorimeter was used to measure the samples' colors. Utilizing the CIE system, instrumental color data was supplied in terms of L* indicating lightness, a* indicating redness and greenness, and b* indicating yellowness and blueness. The total Difference in change in color 'ΔE*' will be calculated using the formula:

$$\Delta E^* = \sqrt{(L^* - L_o^*)^2 + (a^* - a_o^*)^2 + (b^* - b_o^*)^2} \qquad (2)$$

Where, L_o^*, a_o^*, and b_o^* refer to the CIE color values [13] (Borah et al., 2015).

2.6. Drying Kinetics and Behavior

Mathematical modeling for determining the drying kinetics was carried out using the equations in Table 1. The moisture ratio (MR) is the foundation of all models.

$$\text{Moisture Ratio (MR)} = \frac{M_t - M_e}{M_o - M_e} \qquad (3)$$

where Mt is the moisture content after time t; Mo is the initial moisture content; Me is the equilibrium moisture content [14] (Limpaiboon, 2015).

Table 1 Mathematical Modeling Equations for Drying Kinetics

Models	Equations	References
Lewis	MR = exp (-kt)	Lewis, (1921)
Page	MR = exp (-kt^n)	Page, (1949)
Henderson and Pabis	MR = a.exp(-kt)	Henderson, Pabis, (1961)

3. Results and Discussion

3.1. Effect of Drying on The Physical Quality of the Bird's Eye Chilli

The dried chilies using both drying techniques were compared to fresh chilies in terms of physical quality. The fresh green chilies were found to have a moisture content of 78±5% and a water activity of 0.981±0.017, respectively. The sun-dried chillies exhibited a water activity of 0.981±0.017 and a moisture content of 6±2%. The oven-dried chilies were found to have a moisture content of 5±1% and a water activity of 0.551±0.003. ΔE was calculated to estimate the variation in the color change for the drying methods. As the ΔE values for both the drying were higher than 1, it can be determined that the color degrades and the fresh samples become darker. It was determined how the drying techniques affected the chilies' color attributes which is given in Table 1. Studying the various color parameters, and the color variation ΔE, it can be determined that the sun-dried chillies resulted in a better appearance than oven-dried chillies.

3.2. Drying Behavior and Kinetics

The moisture content gradually decreases with time and from the plot of the moisture content and moisture ratio of sun drying and oven drying (at 40°C, 50°C and 60°C) at different drying times, it can be determined that the higher the temperature of drying, the lesser is the time required to completely dry the samples as shown in Figure 3 and Figure 4. The Experimental data were fitted at three mathematical models to study the drying kinetics model parameters as given in Table 3. For sun drying, the best-fitted model was determined to be the Page [16 & 17] model with R2=0.998, and the best-fitted model for oven drying (at 40°C, 50°C and 60°C) was determined to be the [15] Lewis model with R2=0.908 (at 40°C), R2=0.910 (at 50°C) and R2=0.980 (at 60°C).

Table 2 Moisture Content, Water Activity, And Color Quality Parameters of the Samples

Chilli Samples	Moisture content (%)	Water activity (a_w)	Color Quality Parameters			
			L*	a*	b*	ΔE
Fresh	78±5 %	0.981±0.017	53.34±4.32	-13.71±1.17	51.17±4.77	0
Sun-dried	6±2%	0.407±0.004	43.94±2.98	11.14±2.98	36.43±3.89	4.19±4.19
Hot air oven-dried	5±1%	0.551±0.003	42.21±3.45	11.17±1.09	35.37±4.29	4.96±5.10

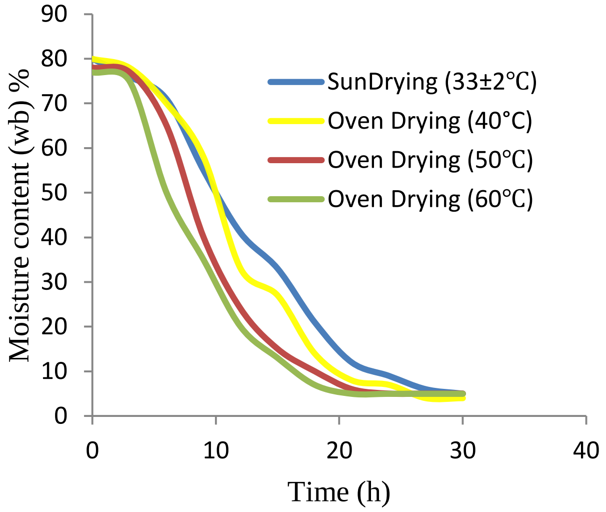

Figure 3 Moisture Content Vs Time Curve

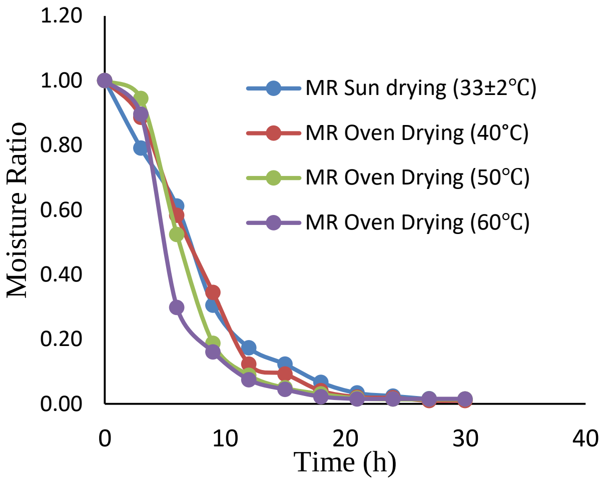

Figure 4 Moisture Ratio Vs Time Curve

Table 3 Drying Kinetics Model Parameters

Models	Method	k	n	R^2
Lewis	Sun drying	0.0121		0.781
	Oven drying at 40°C	0.509		0.908
	Oven drying at 50°C	0.0512		0.910
	Oven drying at 60°C	0.0521		0.980
Page	Sun drying	0.132	1.367	0.998
	Oven drying at 40°C	0.164	1.398	0.710
	Oven drying at 50°C	0.174	1.411	0.711
	Oven drying at 60°C	0.234	1.482	0.723
Henderson and Pabis	Sun drying	0.0110		0.891
	Oven drying at 40°C	0.019		0.812
	Oven drying at 50°C	0.0211		0.823
	Oven drying at 60°C	0.212		0.842

Conclusion

This study was carried out to examined the effects of drying on mizo chilli in the sun and hot air oven (at 40°C, 50°C, and 60°C) drying. It was found that the color changes of the chillies were highly dependent on the temperatures of the drying. With higher temperatures, the color loss increases and thus the sun-dried chillies give a better appearance as compared to hot air oven-dried chillies. Traditional sun drying as compared to hot air oven drying takes longer drying duration and is highly dependent on the climatic conditions. The sun drying gave good quality products but adequate solar radiation is required throughout the drying process and thus it takes more days to completely dry the chillies. The Page model had the best fit for sun drying while the Lewis model provided the best fit for oven drying. With a view to improve the quality of the dried products and reduce the drying time, novel drying technology is recommended.

Acknowledgement

The authors gratefully acknowledge the Department of Food Technology, Mizoram University, for their kind help and providing necessary help to carry out this study.

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